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(54) Abstract Title
User authentication using biometrics

(57) When a fingerprint verifying characteristic extraction section (12) determines that the quality of an image of a fingerprint is insufficient, or when authentication based on an inputted fingerprint by a user verification result determination section (15) results in failure, a request to input a fingerprint is issued from a new-fingerprint-inputting request section (20) to the user. When necessary fingerprint inputting is performed from a new-fingerprint-inputting section (21), substitute authentication by a substitute authentication section (22) is permitted. A result of the substitute authentication by the substitute authentication section (22) is displayed on a service permission-or-rejection display section (24). The image inputted from a fingerprint-inputting section (11) or the new-fingerprint-inputting section (21) is stored into a substitute authentication means user information storage section (23).

FIG. 1

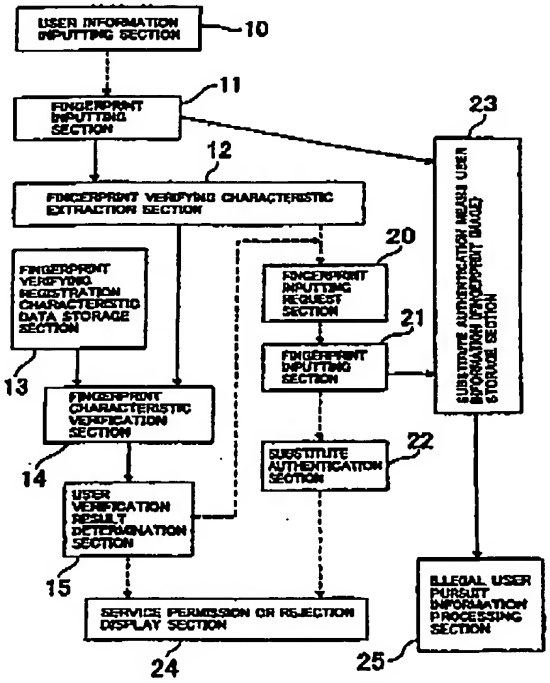

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FIG. 1

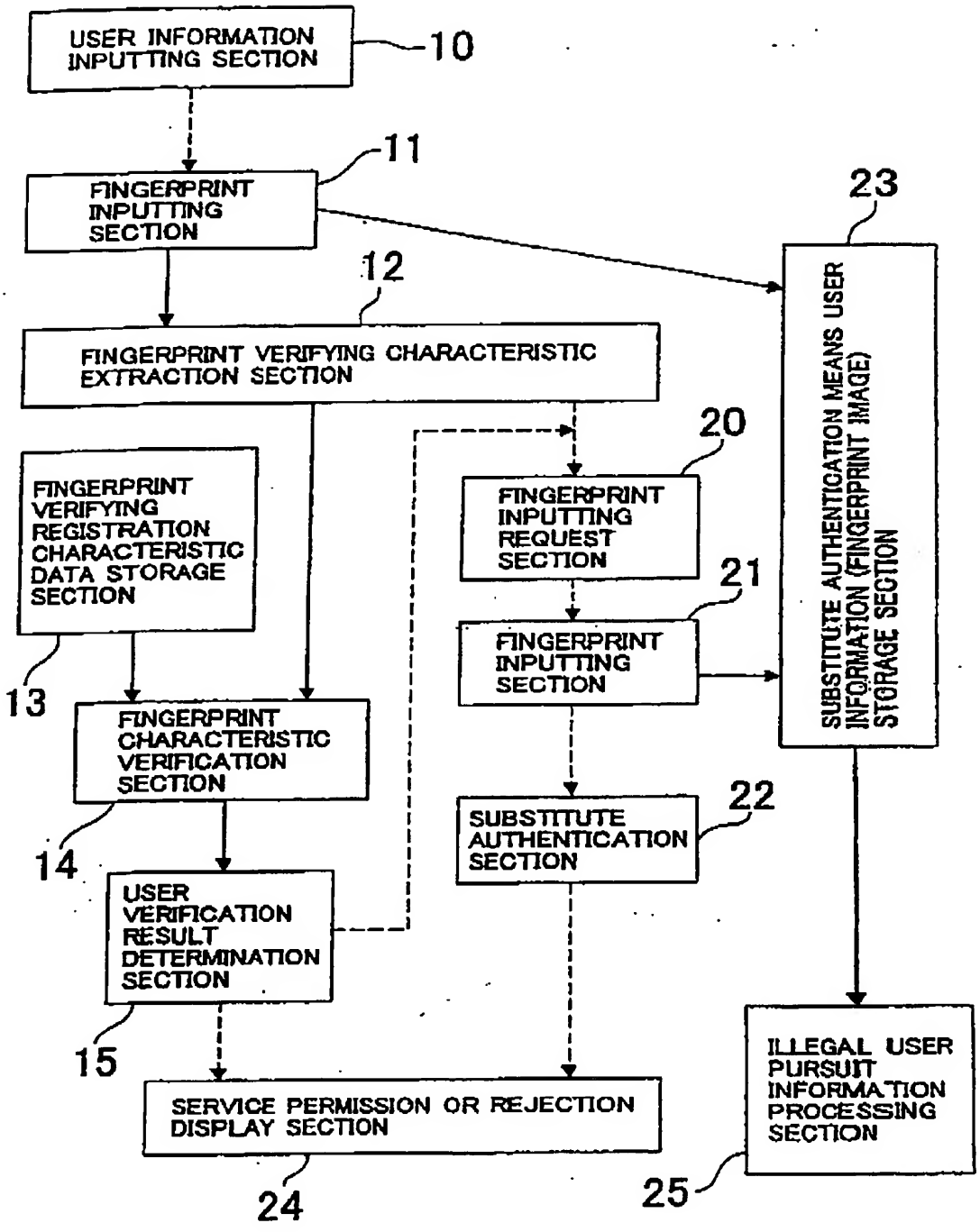

USER INFORMATION INPUTTING SECTION
10
FINGERPRINT INPUTTING SECTION
11
23
12
FINGERPRINT VERIFYING CHARACTERISTIC EXTRACTION SECTION
SUBSTITUTE AUTHENTICATION MEANS USER INFORMATION (FINGERPRINT IMAGE) STORAGE SECTION
20
FINGERPRINT VERIFYING REGISTRATION CHARACTERISTIC DATA STORAGE SECTION
FINGERPRINT INPUTTING REQUEST SECTION
21
FINGERPRINT INPUTTING SECTION
13
FINGERPRINT CHARACTERISTIC VERIFICATION SECTION
SUBSTITUTE AUTHENTICATION SECTION
22
14
USER VERIFICATION RESULT DETERMINATION SECTION
15
SERVICE PERMISSION OR REJECTION DISPLAY SECTION
ILLEGAL USER PURSUIT INFORMATION PROCESSING SECTION
24
25

FIG. 2

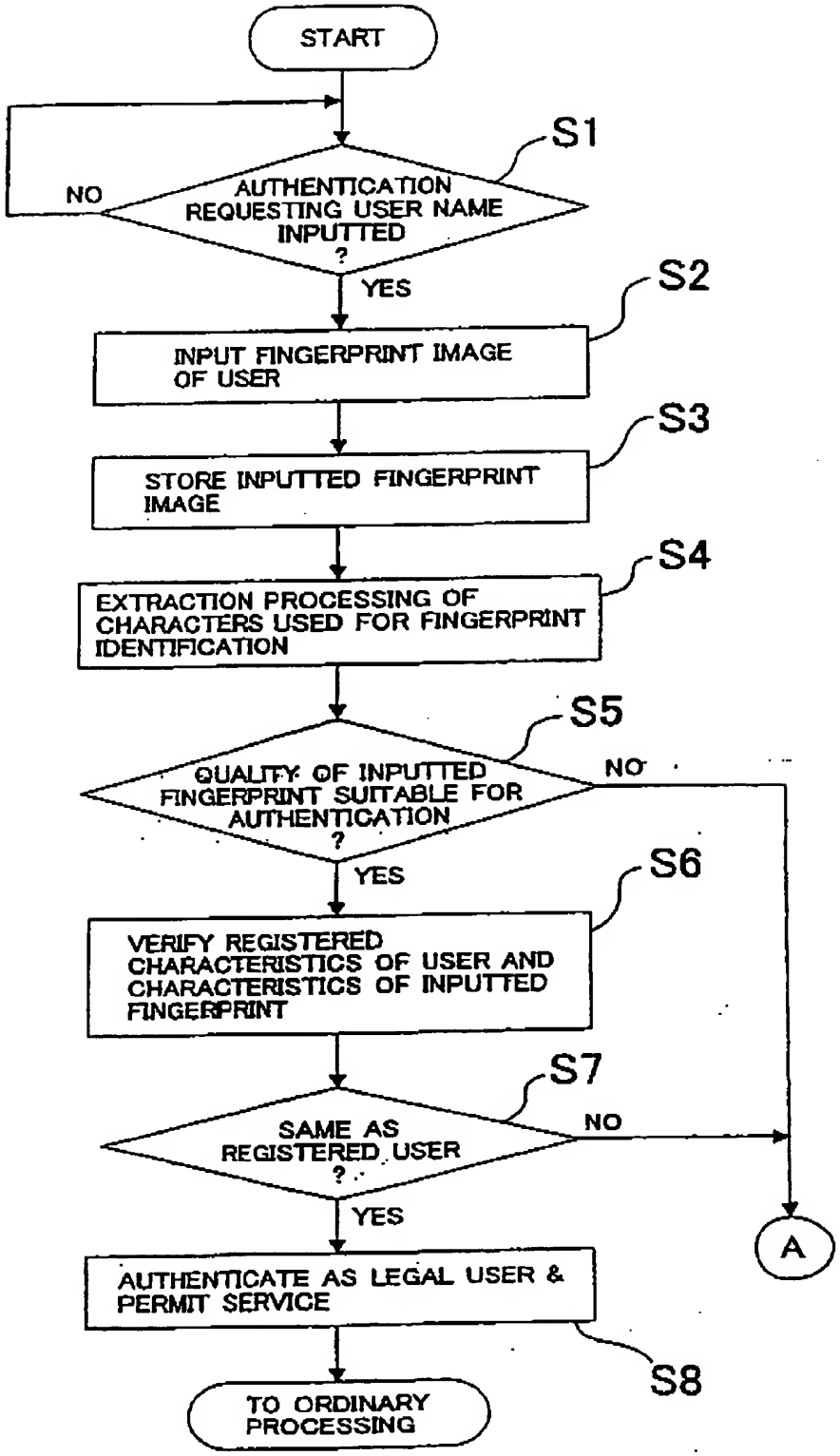

START
S1
AUTHENTICATION REQUESTING USER NAME INPUTTED ?
NO
YES
S2
INPUT FINGERPRINT IMAGE OF USER
S3
STORE INPUTTED FINGERPRINT IMAGE
S4
EXTRACTION PROCESSING OF CHARACTERS USED FOR FINGERPRINT IDENTIFICATION
S5
QUALITY OF INPUTTED FINGERPRINT SUITABLE FOR AUTHENTICATION ?
NO
YES
S6
VERIFY REGISTERED CHARACTERISTICS OF USER AND CHARACTERISTICS OF INPUTTED FINGERPRINT
S7
SAME AS REGISTERED USER ?
NO
YES
A
AUTHENTICATE AS LEGAL USER & PERMIT SERVICE
S8
TO ORDINARY PROCESSING

FIG. 3

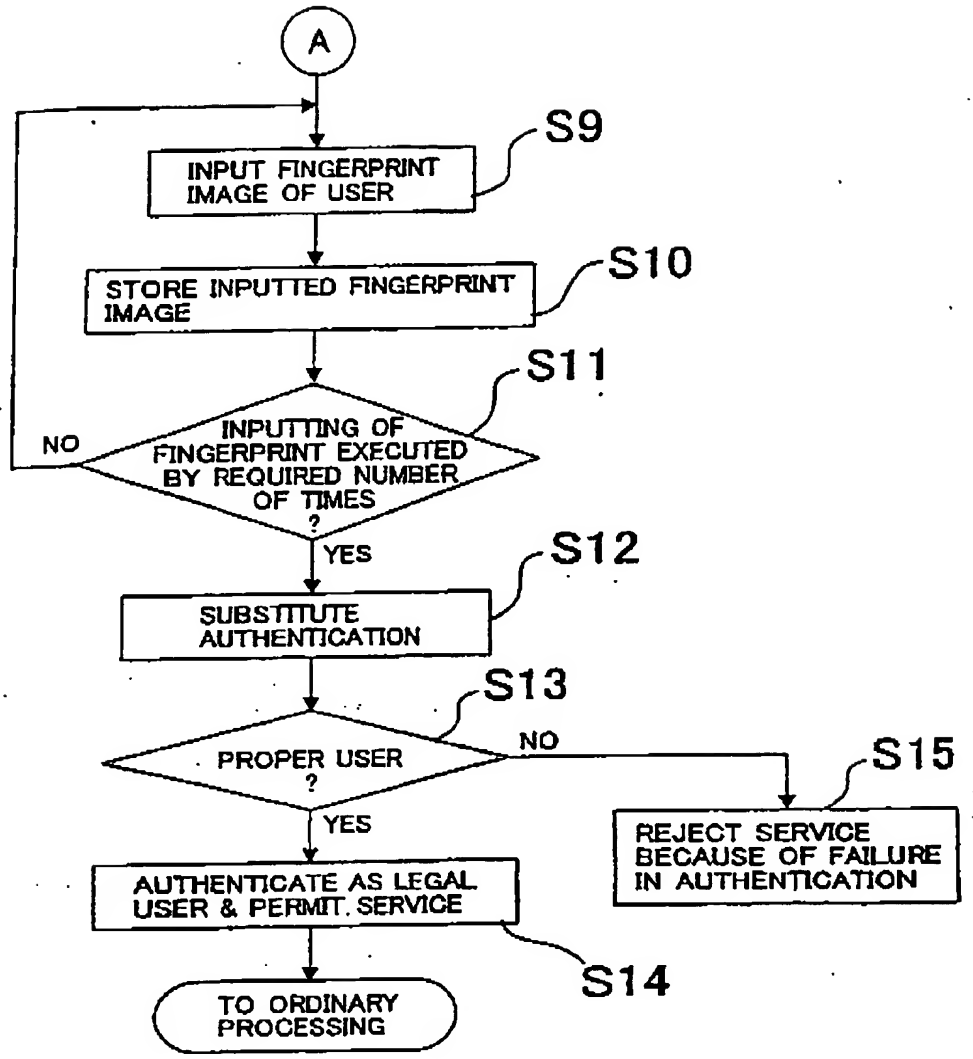

A
S9
INPUT FINGERPRINT IMAGE OF USER
S10
STORE INPUTTED FINGERPRINT IMAGE
S11
INPUTTING OF FINGERPRINT EXECUTED BY REQUIRED NUMBER OF TIMES ?
NO
YES
S12
SUBSTITUTE AUTHENTICATION
S13
PROPER USER ?
NO
S15
REJECT SERVICE BECAUSE OF FAILURE IN AUTHENTICATION
YES
AUTHENTICATE AS LEGAL USER & PERMIT. SERVICE
S14
TO ORDINARY PROCESSING

FIG. 4

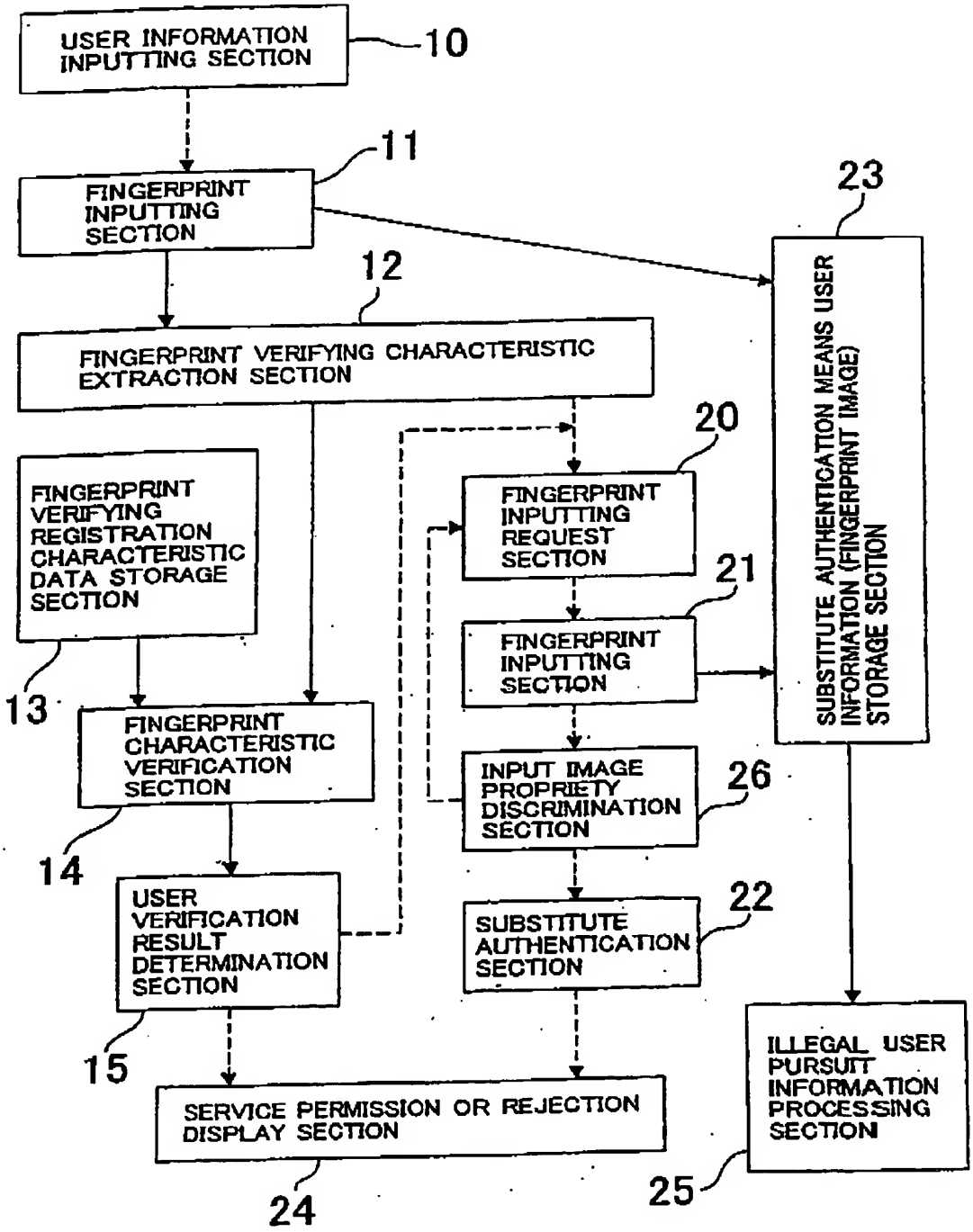

USER INFORMATION INPUTTING SECTION
10
FINGERPRINT INPUTTING SECTION
11
23
12
FINGERPRINT VERIFYING CHARACTERISTIC EXTRACTION SECTION
20
FINGERPRINT VERIFYING REGISTRATION CHARACTERISTIC DATA STORAGE SECTION
FINGERPRINT INPUTTING REQUEST SECTION
21
FINGERPRINT INPUTTING SECTION
SUBSTITUTE AUTHENTICATION MEANS USER INFORMATION (FINGERPRINT IMAGE) STORAGE SECTION
13
FINGERPRINT CHARACTERISTIC VERIFICATION SECTION
INPUT IMAGE PROPRIETY DISCRIMINATION SECTION
26
14
USER VERIFICATION RESULT DETERMINATION SECTION
SUBSTITUTE AUTHENTICATION SECTION
22
15
SERVICE PERMISSION OR REJECTION DISPLAY SECTION
ILLEGAL USER PURSUIT INFORMATION PROCESSING SECTION
24
25

FIG. 5

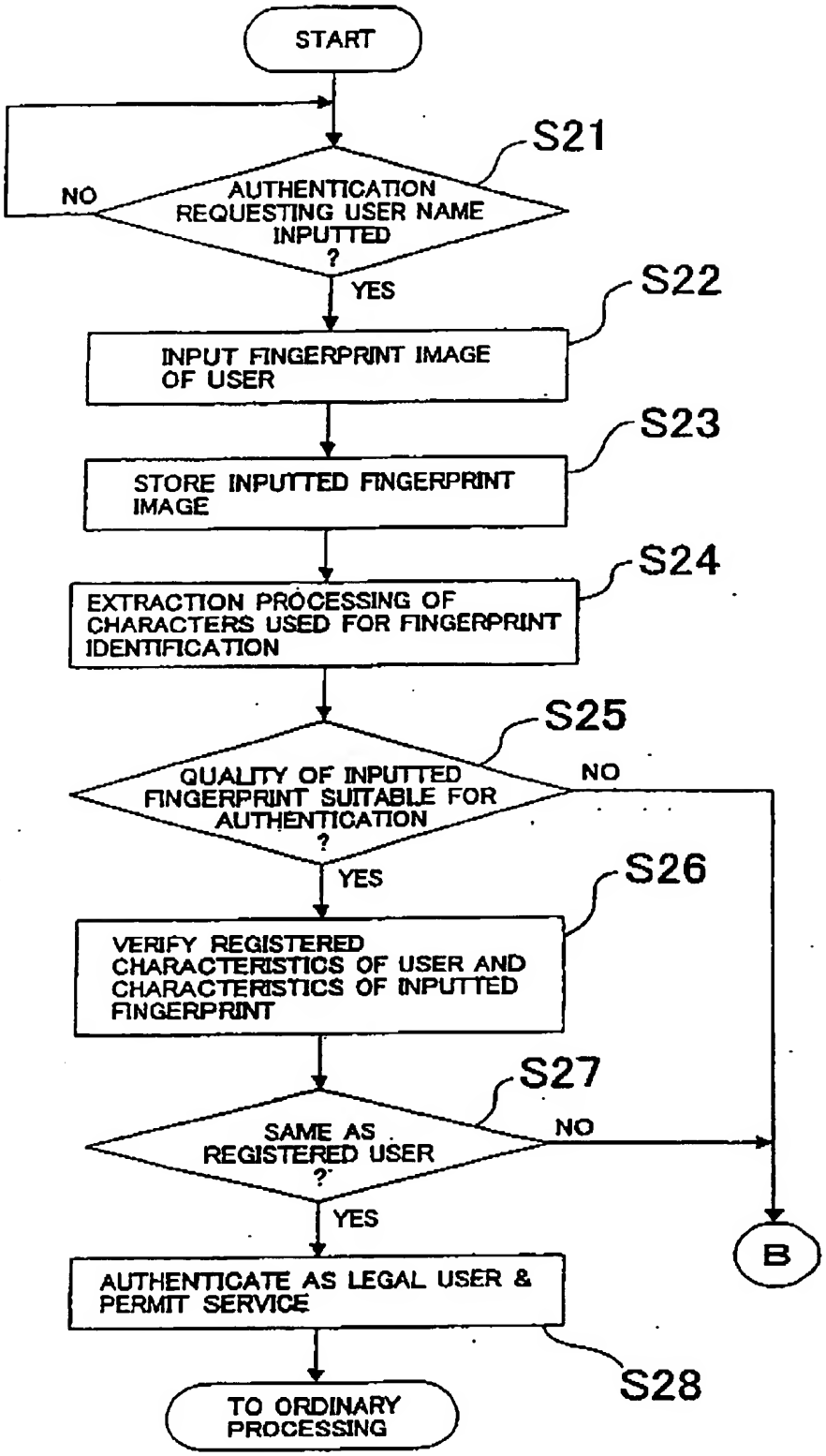
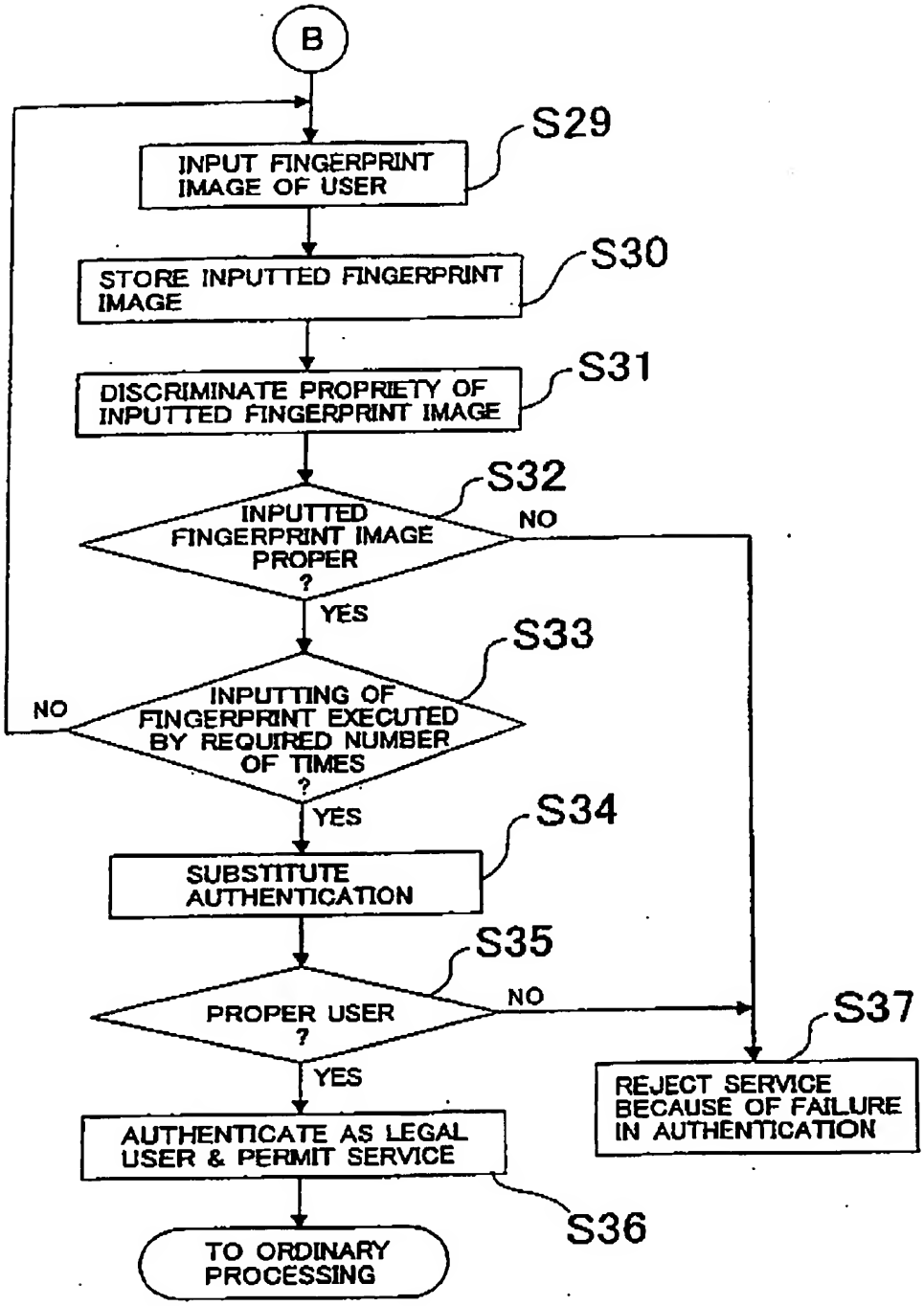

START
S21
AUTHENTICATION REQUESTING USER NAME INPUTTED ?
NO
YES
S22
INPUT FINGERPRINT IMAGE OF USER
S23
STORE INPUTTED FINGERPRINT IMAGE
S24
EXTRACTION PROCESSING OF CHARACTERS USED FOR FINGERPRINT IDENTIFICATION
S25
QUALITY OF INPUTTED FINGERPRINT SUITABLE FOR AUTHENTICATION ?
NO
YES
S26
VERIFY REGISTERED CHARACTERISTICS OF USER AND CHARACTERISTICS OF INPUTTED FINGERPRINT
S27
SAME AS REGISTERED USER ?
NO
YES
B
AUTHENTICATE AS LEGAL USER & PERMIT SERVICE
S28
TO ORDINARY PROCESSING

FIG. 6


B
S29
INPUT FINGERPRINT IMAGE OF USER
S30
STORE INPUTTED FINGERPRINT IMAGE
S31
DISCRIMINATE PROPRIETY OF INPUTTED FINGERPRINT IMAGE
S32
INPUTTED FINGERPRINT IMAGE PROPER ?
NO
YES
S33
INPUTTING OF FINGERPRINT EXECUTED BY REQUIRED NUMBER OF TIMES ?
NO
YES
S34
SUBSTITUTE AUTHENTICATION
S35
PROPER USER ?
NO
YES
S37
REJECT SERVICE BECAUSE OF FAILURE IN AUTHENTICATION
AUTHENTICATE AS LEGAL USER & PERMIT SERVICE
S36
TO ORDINARY PROCESSING

USER AUTHENTICATION APPARATUS AND METHOD USING BIOMETRICS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a user authentication apparatus which uses biometrics and a user authentication method for use with the user authentication apparatus, and more particularly to a method wherein a user is authenticated with biometrics such as a fingerprint upon management of physical accessing at a gate or the like or upon management of information accessing on a terminal such as a personal computer.

Description of the Related Art

Conventionally, a user authentication method is used to confirm whether or not a user who manages, for instance, physical accessing for entry at a gate, or manages an information access right on a terminal such as a personal computer, is the authorised person.

In the user authentication method, authentication based on biometrics is used in addition to a method of performing authentication depending upon whether or not the user possesses a certain article, such as a magnetic card, or whether or not the user has secret knowledge such as a personal identification number or a password.

Authentication based on biometrics makes use of a biological characteristic unique to each individual, such as a fingerprint. A fingerprint is a pattern of the skin at a fingertip of the human being. It is known that the fingerprint has characteristics that "it is different among different people" and "it does not vary till the end of the person's life". Even if the cuticle of a fingertip is damaged, the same fingerprint restores to the original state from the invariable corium in the interior of the cuticle. Therefore, the fingerprint is widely known as biometrics that allows accurate identification of an individual.

For example, in a user authentication process when someone requests accessing, the person is urged to input their fingerprint. When a fingerprint is inputted, it can be used in the following manner. In particular, if the fingerprint coincides with a registered fingerprint, then the accessing is permitted, but if the fingerprint does not coincide with the registered fingerprint, then it is determined that the person is an illegal user and the accessing of the person is not permitted.

Where authentication based on a possessed article is used, an unrelated person who picked up the possessed article can use it. Also where authentication based on knowledge is used, if a person making a random guess of the knowledge inputs the knowledge, then they can acquire illegal accessing permission. In contrast, according to the method that is based on biometrics, a function wherein the authorised person can obtain

authentication is realized.

Such a technique as described above is disclosed, for example, in Japanese Patent Laid-Open No. 33065/1992.

In the conventional user authentication method described above, where a system is employed wherein biometrics such as, for example, a fingerprint is inputted and compared with registered verification characteristics to confirm authorization of the person, presence of a user with whom registration or verification does not result in success, when the quality of the fingerprint image is deteriorated by drying of or damage to the finger, cannot be ignored.

When registration or verification of a fingerprint does not result in success, typically an evading method which substitutes another authentication scheme such as, for example, inputting of a password is used. According to the method, a fingerprint is inputted, and if it does not have a quality sufficient to allow automatic verification, then automatic authentication based on the fingerprint is given up and a password is inputted from a keyboard as a substitute measure. However, where a password is used, an unrelated person can pose as the person through devious means. This makes a security hole in the entire system, which is a disadvantage of the method described above.

Naturally, it is possible to additionally use, where a fingerprint is not suitable for automatic authentication, verification based on some other biometrics such as, for example, the iris. In this instance, however, an additional

cost for installation and operation of an inputting apparatus for an iris image, such as a camera, an illumination system for obtaining a stabilised image and so forth, is required, and an increase in cost cannot be avoided.

SUMMARY OF THE INVENTION

It is an object of the preferred embodiments of the present invention to provide a user authentication method and a user authentication apparatus by which, even where biometrics input data, such as a fingerprint, of a user are low in quality and are not suitable for verification, the security of the entire system can be augmented without giving rise to an increase in cost by introduction of significant additional hardware.

According to an aspect of the present invention, there is provided a user authentication apparatus, comprising: authentication means for authenticating a user by verification of the user by biometrics data of that user, such data representing a biological characteristic unique to an individual; acquisition means, operable when the authentication by the authentication means results in failure in the verification of the biometrics data for acquiring new biometrics data of the user for whom authentication has been requested; and, substitute authentication means for substituting the verification of the biometrics data with the new biometrics data when the new biometrics data is acquired by the acquisition means.

According to another aspect of the present invention,

there is provided a user authentication method, comprising the steps of: authenticating a user by verification of the user by biometrics data of that user, such data representing a biological characteristic unique to an individual; acquiring, when the authentication results in failure in the verification of the biometrics data, new biometrics data of the user for whom authentication has been requested; and, performing substitution authentication for substituting the verification of the biometrics data with the new biometrics data when the new biometrics data is acquired by the acquisition means.

Preferably, the user authentication method further comprises a step of storing the new biometrics data acquired by the step of acquiring the new biometrics data, and a step of performing search and pursuit of an illegal user based on the stored new biometrics data.

Alternatively, the user authentication method may further comprise a step of determining whether or not new biometrics data inputted so as to be used for the verification of biometrics have a quality suitable for automatic verification, and a step of storing the newly-acquired biometrics data when it is determined that the biometrics data do not have a quality suitable for automatic comparison. The user authentication method may further comprise a step of determining, when it is determined that the new biometrics data do not have a quality suitable for automatic comparison, whether or not the new biometrics data have a quality suitable for use for the search and the pursuit of an illegal user, and wherein, when it is

determined that the new biometrics data are suitable for use for the search and the pursuit of an illegal user, use of the substitute authentication is permitted. The determination of whether or not the new biometrics data are suitable for use for the search and the pursuit of an illegal user may depend upon determination of whether or not the newly-inputted biometrics data are proper and are inputted by the user at the place that is used. A correlation of a plurality of new biometrics data acquired by the step of acquiring the new biometrics data may be measured to determine whether or not the new biometrics data are inputted by the user at the place of the user.

At least a fingerprint may be used as the biometrics.

Upon storage of new biometrics data prior to the substitute authentication, at least a photographic image of a face and/or a figure of a user may be taken when a fingerprint is inputted.

In the user authentication apparatus and the user authentication method, if authentication by verification of biometrics data results in failure, then new biometrics data of the user for whom authentication has been requested are acquired, and verification of biometrics data is substituted after the new biometrics data of the user are acquired. Therefore, when it later becomes clear that illegal accessing of entry to a gate or illegal log-in to a computer system was executed, the person who posed illegally can be specified. Consequently, the user authentication apparatus and the user authentication method are advantageous in that, even where

biometrics input data, such as a fingerprint of a user are low in quality and are not suitable for verification, the security of the entire system can be augmented without giving rise to an increase in cost by introduction of significant additional hardware.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred features of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:-

FIG 1 is a block diagram showing a configuration of a user authentication apparatus to which the present invention is applied;

FIGS 2 and 3 are flowcharts illustrating operation of the user authentication apparatus of FIG. 1;

FIG 4 is a block diagram showing a configuration of another user authentication apparatus to which the present invention is applied; and

FIGS. 5 and 6 are flowcharts illustrating operation of the user authentication apparatus of FIG.4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIG. 1, there is shown a configuration of a user authentication apparatus to which the present invention

is applied. In the user authentication apparatus of the present embodiment, a fingerprint is used as biometrics. It is to be noted that broken lines in FIG. 1 indicate a flow of a processing procedure (control) and solid lines indicate a flow of data such as fingerprint data.

The user authentication apparatus includes a user information inputting section 10, a fingerprint inputting section 11, a fingerprint verifying characteristic extraction section 12, a fingerprint verifying registration characteristic data storage section 13, a fingerprint characteristic verification section 14, a user verification result determination section 15, a fingerprint inputting request section 20, a fingerprint inputting section 21, a substitute authentication section 22 based on an inputted password, a substitute authentication means user information storage section 23, a service permission or rejection display section (hereinafter referred to simply as display section) 24, and an illegal user pursuit information processing section 25.

FIGS. 2 and 3 illustrate operation of the user authentication apparatus of FIG. 1, and operation of the user authentication apparatus is described with reference to FIGS. 1 to 3. It is to be noted that the processing operation illustrated in FIGS. 2 and 3 can be realized by the components of the user authentication apparatus which execute a program stored in a control memory not shown of the user authentication apparatus. The control memory may be a ROM (Read Only Memory), an IC

(Integrated Circuit) memory or a like memory.

A user name of a user who requests for authentication in order to request for provision of a service is inputted from the user information inputting section 10 (step S1 of FIG. 2). Upon inputting of a user name, a user number may be inputted from ten keys or a user identifier is inputted from a keyboard, or otherwise an ID (Identification number) card of the magnetic type or the like may be used for such inputting.

In order to input a fingerprint image of the user, the fingerprint inputting section 11 picks up a fingerprint image of the user when a finger of the user touches with a fingerprint sensor (not shown). The fingerprint inputting section 11 further converts the image data of the fingerprint image into digital image data so as to allow later processing in the user authentication apparatus (step S2 of FIG. 2).

As a scheme of configuration of the fingerprint sensor, an optical system can be used wherein light emitted typically from an LED (Light Emitting Diode) is reflected by a prism and then converted into a digital image using a CCD (Charge Coupled Device). The conversion is performed utilizing the fact that the reflection factor is different between a ridge portion and a valley portion along a ridge of a finger placed on the outer side of the reflecting surface of the prism.

The fingerprint verifying characteristic extraction section 12 receives the fingerprint image obtained from the fingerprint inputting section 11 and executes a process of

extracting characteristics for use for identification of the fingerprint from the fingerprint image (step S4 of FIG. 2).

A method of realizing extraction of characteristics for use for identification of a fingerprint is disclosed, for example, in Hiroshi Asai, Yukio Hoshino and Kazuo Kiji, "Automated Fingerprint Identification by Minutiae-Network Feature --Feature Extraction Processes--", the Transactions of the Institute of Electronics, Information, and Communication Engineers of Japan, Vol. J72-D-II, No. 5, May, 1989, pp.724-732.

According to the method disclosed in the document, a ridge pattern is extracted from a variable density image including ridges by a binary digitization process and a thinning process, and positions of an end point and a branching point of any ridge are detected. Then, the number of intersecting ridges on a line segment interconnecting the end point and the branching point of the ridge is counted, and the relationship diagram is represented in digital data and used as fingerprint characteristics for verification.

In the process described, also the area of a region of the fingerprint image in which the image quality is sufficiently high to extract characteristics, the number of characteristics such as end points and branching points obtained by the characteristic extraction, reliability information applied to each characteristic by the automatic characteristic extraction process and other necessary information are calculated as additional information.

Further, the fingerprint verifying characteristic extraction section 12 discriminates based on a result of the characteristic extraction whether or not the inputted fingerprint has a quality suitable for authentication for which automatic fingerprint verification is used (step S5 of FIG. 2). In order to allow automatic fingerprint verification, it is necessary that the contrast in concave and convex geometry between ridges of the fingerprint and valleys between the ridges be sufficiently great. However, a fingerprint image is not sometimes obtained with a required quality particularly when the skin is dry or because of perspiration, damage, abrasion or the like of the skin. In such a case, it is discriminated that the fingerprint image has an insufficient quality.

In an available method of realizing the discrimination, it is discriminated whether or not typically the area of the region in which the image has a quality sufficiently high to extract characteristics, the numbers of the individual characteristics such as end points and branching points obtained from the characteristic extraction, the reliability information applied to the individual characteristics by the automatic characteristic extraction processing and so forth all obtained by the fingerprint verifying characteristic extraction section 12 individually or in combination are higher than threshold values for them determined in advance.

The fingerprint verifying registration characteristic data storage section 13 stores fingerprint characteristic

information for verification and user unique information regarding the user who is the owner of the fingerprint in a corresponding relationship to each other. The user unique information includes information for identification of the user and types, ranges and so forth of services permitted to the user.

If the fingerprint verifying characteristic extraction section 12 discriminates that the fingerprint image has a sufficient quality, then the fingerprint characteristic verification section 14 verifies the fingerprint image to detect whether or not the registered characteristics regarding the user and the characteristics of the inputted fingerprint coincide with each other, that is, are sufficiently analogous to each other (step S6 of FIG. 2).

The fingerprint characteristic verification section 14 receives the fingerprint characteristics S determined from the fingerprint inputted by the user this time from the fingerprint verifying characteristic extraction section 12. Further, the fingerprint characteristic verification section 14 receives the fingerprint characteristic information F corresponding to the user name inputted as the user information from within the fingerprint characteristic information stored till then from the fingerprint verifying registration characteristic data storage section 13. Then, the fingerprint characteristic verification section 14 compares the fingerprint characteristic information F and the fingerprint characteristics S with each

other and evaluates a score representative of a similarity which has a high value when the two kinds of information originate from the same finger.

The fingerprint characteristic verification section 14 compares the score with a threshold value set therefor in advance to discriminate whether or not the user which has given the fingerprint characteristics S is the same as the registered user (step S7 of FIG. 2). If the score is higher than the threshold value, then the fingerprint characteristic verification section 14 outputs an identification result of "the fingerprint coincides".

A typical method of realizing the verification for identification of an imprinting person using a fingerprint as described above is disclosed, for example, in Hiroshi Asai, Yukio Hoshino and Kazuo Kiji, "Automated Fingerprint Identification by Minutiae-Network Feature --Verification Processes--", the Transactions of the Institute of Electronics, Information, and Communication Engineers of Japan, Vol. J72-D-II, No. 5, May, 1989, pp.733-740.

According to the method disclosed in the document, for each of two fingerprints for verification, the number of ridges intersecting with a line segment interconnecting an end point and a branching point of a ridge is counted and represented in digital data. The digital data are used for positioning of the fingerprints relative to each other, and the similarity between them is evaluated to realize verification.

When a result of the fingerprint verification indicates that the inputted fingerprint is sufficiently similar to the stored fingerprint characteristics stored with regard to the user, the user verification result determination section 15 authenticates that the user who has inputted the user information is the legal user and displays on the display section 24 that a service is permitted (step S8 of FIG. 2). On the other hand, when the fingerprint does not coincide, the user verification result determination section 15 determines that the authentication results in failure and rejects a service, and the fingerprint inputting request section 20 subsequently executes processing of performing substitute authentication.

The processing operation described above is performed when the fingerprint verifying characteristic extraction section 12 discriminates that the quality is sufficient to perform automatic verification. On the other hand, however, when the fingerprint verifying characteristic extraction section 12 discriminates that the quality is insufficient or when the authentication with the inputted fingerprint by the user verification result determination section 15 results in failure, the fingerprint inputting request section 20 issues a request to input a fingerprint to the fingerprint sensor by a plural number of times to the user (step S9 to S11 of FIG. 3). The reason why it is requested to input a fingerprint by a plural number of times is that it is intended to find out and exclude inputting of a spurious fingerprint thereby.

The fingerprint inputting section 21 performs inputting and acquisition of a fingerprint using a scheme similar to the fingerprint inputting section 11. Only when necessary fingerprint inputting is performed from the fingerprint inputting section 21 in accordance with the request of the fingerprint inputting request section 20, the user can advance to a next substitute authentication step by the substitute authentication section 22 (step S12 of FIG. 3).

As a substitute authentication method by the substitute authentication section 22, typically a method of inputting a personal identification number or a password from ten keys or a keyboard or another method of reading in from a magnetic card for certifying the holding person is available. If it is discriminated by one of the substitute authentication methods that the user is a legal user (step S13 of FIG. 3), then similarly as when it is authenticated by the biometrics automatic verification described above that the user is a legal user, it is authenticated that the user who has inputted the user information is a legal user, and it is displayed on the display section 24 that a service is permitted (step S14 of FIG. 3). In any other case, it is discriminated that the authentication results in failure, and it is displayed on the display section 24 that a service is rejected (step S15 of FIG. 3).

The substitute authentication means user information storage section 23 stores the image inputted first from the fingerprint inputting section 11 and the image inputted from

the fingerprint inputting section 21 after the request by the fingerprint inputting request section 20 (step S3 of FIG. 2 and step S10 of FIG. 3). The stored images are later used for search and pursuit of an illegal user by the illegal user pursuit information processing section 25 when necessary.

Referring now FIG. 4, there is shown a configuration of another user authentication apparatus to which the present invention is applied. The user authentication apparatus according to the present embodiment has a configuration similar to but different from that of the user authentication apparatus according to the present embodiment shown in FIG. 1 in that it additionally includes an input image propriety discrimination section 26. The common components operate in a similar manner as those of the user authentication apparatus of the first embodiment, and overlapping description of them is omitted herein to avoid redundancy.

FIGS. 5 and 6 illustrate operation of the user authentication apparatus of FIG. 4, and operation of the user authentication apparatus is described with reference to FIGS. 4 to 6. It is to be noted that the processing operation illustrated in FIGS. 5 and 6 can be realized by the components of the user authentication apparatus which execute a program stored in the control memory not shown of the user authentication apparatus. The control memory may be a ROM, an IC memory or a like memory.

Of the processing operations illustrated in FIGS. 5 and 6, the operations in steps S21 to S30 and S33 to S37 are similar

to the operations in steps S1 to S8 of FIG. 2 and steps S9 to S15 of FIG. 3, respectively. Thus, different or characteristic operations of the user authentication apparatus according to the second embodiment are described below.

In the user authentication apparatus according to the present embodiment, similarly as in the user authentication apparatus according to the first embodiment, when it is determined by the user authentication result determination section 15 that authentication based on a fingerprint inputted results in failure and substitute authentication by the substitute authentication section 22 is required, a request to input a fingerprint to the fingerprint sensor is issued from the fingerprint inputting request section 20 to the user. Consequently, the fingerprint inputting section 21 (step S29 of FIG. 6 acquires a fingerprint image).

The input image propriety discrimination section 26 discriminates whether or not the fingerprint image inputted from the input sensor is an image of a fingerprint of a finger presented properly by the user who requests for authentication for a service at present (steps S30 and S31 of FIG. 6).

Such images as given below should be discriminated and eliminated by the discrimination of the input image propriety discrimination section 26. In particular, (1) an image of a biological element presented by the user other than a fingerprint such as, for example, a portion of a finger other than a fingerprint, part of a palm, or a portion of the skin of some

other part, and (2) an image of an element presented by the user which is not a biological part but imitates a fingerprint such as, for example, an element which is made imitating a finger from a material similar to the human body such as rubber or silicon and besides has a fingerprint of an unrelated person applied to the surface thereof, should be eliminated.

In order to eliminate presentation of an image based on such an imitated finger as described above, the input image propriety discrimination section 26 first evaluates a likelihood of the image to a fingerprint and uses as a criterion that the fingerprint likelihood is higher than a threshold value. For the evaluation of the fingerprint likelihood, a method is used wherein the image is divided into small regions and two-dimensional Fourier transform or the like is used for each of the small regions to determine a frequency distribution.

The ridges of a fingerprint of a human being have a stripe pattern having a pitch distribution restricted to some degree, and this can be confirmed by evaluating the distribution of peaks in the frequency distribution. Even if a fingerprint partially has a quality which is not suitable for automatic verification because it is damaged or is dry at the portion, the fingerprint must have a wide region over which its stripe pattern can be observed. The fingerprint and other portions can be distinguished from each other by the method just described.

In order to confirm that an element presented is a finger of a living body, a method of checking the similarity between

a plurality of input images is used. A finger of a human being is resilient, and the possibility is high that the manner of deformation of a finger may be different each time it is impressed. If a plurality of impressed images coincide with each other even in their details, it is reasonable to determine that an imitated item (replica) having a resiliency different from that of a finger of a living body is presented and is not a proper impression.

Accordingly, if the positional correlation of the ridge pattern between a plurality of fingerprint images is significantly high when they are relatively positioned by parallel movement and revolution, then it is considered that the source of the image is a body which has rigidity to some degree. Then, by evaluating the degree, the body can be discriminated from the skin of a finger which has resiliency and must necessarily exhibit a different manner of deformation each time it is impressed.

Further, it is possible to pick up moving pictures while the impression area becomes wider after impression inputting of a finger is started on the input sensor and then becomes narrower until the impression is completed and evaluate the degree of deformation of the finger by its resiliency then from the obtained image sequence in the temporal direction to discriminate an input which does not match the resiliency of the finger. Also it is possible to use a method of checking whether or not sweat gland holes are present on a fingerprint

image. Since sweat gland holes have a very fine structure on ridges, it is considered considerably difficult to work and imitate them on a replica.

Only when it is determined by such discrimination of the input image propriety discrimination section 26 as described above that the input image is a legal fingerprint input, the user can advance to the substitute authentication step by the substitute authentication section 22.

As a substitute authentication method by the substitute authentication section 22, typically a method of inputting a personal identification number or a password from ten keys or a keyboard or another method of reading in from a magnetic card for certifying the holding person is available. If it is discriminated by one of the substitute authentication methods that the user is a legal user, then similarly as when it is authenticated by the biometrics automatic verification described above that the user is a legal user, it is authenticated that the user who has inputted the user information is a legal user. Consequently, a service is permitted. In any other case, it is discriminated that the authentication results in failure, and a service is rejected.

The substitute authentication means user information storage section 23 stores the inputted image after the request by the fingerprint inputting request section 20 (step S30 of FIG. 6). The stored image is later used for search and pursuit of an illegal user by the illegal user pursuit information

processing section 25 when necessary.

The configurations and the operations of the components of the first embodiment and the second embodiment of the present invention are described above, and in the following, examples of use of them are described. The present invention is applied typically to passer management (physical access control) through an entrance gate of important facilities, log-in management to a computer system which includes important information and so forth.

For example, in operation in a physical access control application, a user who requests for entry inputs a number N or the like for identification of the user itself from ten keys or the like and inputs a fingerprint S from the fingerprint sensor. The system discriminates coincidence between the fingerprint S and a fingerprint F which is identified with the inputted identification number N of the user from among a plurality of registered fingerprints stored therein. In actual verification, the similarity of characteristics for verification extracted from the fingerprint S and the fingerprint F is evaluated, and if the similarity is higher than a threshold valve, then it is determined that they coincide with each other.

The verification processing is performed automatically, and when the quality of the inputted fingerprint is not sufficient, it cannot be discriminated with sufficient confidence whether or not the fingerprints are of the same finger. When the user

inputs a fingerprint of such a low quality as just described, conventionally a method is usually employed wherein it is determined that "authentication by an automatic verification process is impossible" and, as substitute measures, a request to input a special personal identification number or password is issued. Then, if an inputted personal identification number or password coincides with a registered one, then it is determined that the authentication results in success.

In the present system, when automatic verification does not result in success because the quality of an inputted image of a finger is insufficient, the fingerprint image inputted first is stored into the substitute authentication means user information storage section 23 and a request to input a fingerprint is issued again before substitute authentication is permitted.

The reason why a request to input a fingerprint is issued by a plural number of times in this manner is that it is intended to prevent an image of a counterfeit finger from being given and stored as it is. In order to prevent such storage of a counterfeit finger, a plurality of fingerprint images are compared with each other or a time series of images obtained from moving pictures which record a fingerprint impression are utilized as described hereinabove. The propriety of a plurality of images or a time series of images inputted is discriminated by the input image propriety discrimination section 26, and if the images are not of a fingerprint of a living body, substitute

authentication is not permitted.

If an image inputted is a proper image, then this is stored into the substitute authentication means user information storage section 23, and the processing advances to substitute authentication by the substitute authentication section 22 which is based on inputting of a password. If the inputted password or personal identification number coincides with a registered one, then it is determined that the user is authenticated properly, and the user can enjoy a service.

The password or personal identification number inputted from ten keys, a keyboard or the like for substitute authentication can be entered even by an unrelated person through conjecture, furtive looking or the like, and this gives rise to the possibility of illegal accessing by a person who poses as the legal user. The present system provides measures for specifying, when it later becomes clear that illegal accessing to entrance gate management or illegal log-in to a computer system was executed, the person who posed illegally.

In particular, images stored in the substitute authentication means user information storage section 23 include fingerprint information of users who utilized the substitute authentication section 22 and can be utilized for search and pursuit of an illegal user by a manager or the like who visually observes the images. Since the range of users of such a system is limited in most cases, much information for pursuit can be obtained by visually comparing fingerprints

of the users and the stored images with each other. This can be utilized for discovery or pursuit of an illegal user.

Although, in the forgoing description, a method wherein a fingerprint of a single finger is used as biometrics data is described, naturally it is possible to augment the security by inputting a plurality of fingers and using the fingers to discriminate the propriety of the input image (whether the user presents the living fingers properly) more strictly or by storing a fingerprint image of a plurality of fingers and using them for pursuit of an illegal user.

Further, while an example wherein user identification information is inputted from the user information inputting section 10 before a fingerprint is inputted is described, this is not necessarily essential. Where the fingerprint inputting by the fingerprint inputting section 11 is performed without inputting user identification information, the following procedure may be taken. First, extraction of characteristics from the inputted fingerprint is performed. Then, the fingerprint characteristic verification section 14 verifies the obtained characteristics successively with all of the fingerprint characteristic data stored in the fingerprint verifying registration characteristic data storage section 13. Further, the fingerprint characteristic verification section 14 permits a service or services to be provided to a registered user of the fingerprint which has the highest similarity score.

Although the first and second embodiments of the present

invention are described taking a fingerprint as an example of biometrics, if the fingerprint sensor is replaced with a structure which accepts inputting of another type of biometrics (a biological characteristic unique to an individual) for automatic verification to allow extraction and verification of characteristics, then other biometrics such as a palm print, the face, an iris, a retina blood vessel pattern, a fist, handwriting, and a voiceprint can be used instead.

Also it is possible to use a fingerprint in ordinary biometrics authentication but use some other biometrics in storage of biometrics data prior to substitute authentication separately from or together with the fingerprint. For example, an image of the face may be picked up upon substitute authentication, or an image of a figure when a fingerprint is inputted may be picked up. Picking up of an image in a fingerprint inputting process by means of another camera can be utilized for discrimination of the propriety of whether or not a fingerprint is inputted properly by the input image propriety discrimination section 26. This is an effective method of storing information which exhibits its effect in later processing for pursuit of an illegal user.

In this manner, in searching for an attacker to the system who uses a service request posing as a related person and is a menace to authentication, stored fingerprint images can be used for a substitute authenticator.

Even if the stored fingerprint images have a quality

insufficient for automatic verification upon log-in, they provide such information that is useful for manual search for an attacker. Since deception with a counterfeit finger is eliminated by the input image propriety discrimination section 26, an image indicates a clue or evidence regarding the attacker. Further, the fact that a fingerprint image of the person is demanded also when a password is inputted has a deterrent effect against a pending attack, and is effective to augment security of the entire system.

While preferred embodiments of the present invention have been described using specific terms, such description is for illustrative purposes only, and it is to be understood that changes and variations may be made without departing from the scope of the following claims.

Each feature disclosed in this specification (which term includes the claims) and/or shown in the drawings may be incorporated in the invention independently of other disclosed and/or illustrated features. Reference numerals appearing in the claims are by way of illustration only and should be disregarded when interpreting the scope of the claims.

The text of the abstract filed herewith is repeated here as part of the specification.

When a fingerprint verifying characteristic extraction section determines that the quality of an image of a fingerprint is insufficient, or when authentication based on an inputted fingerprint by a user verification result deter-

mination section results in failure, a request to input a fingerprint is issued from a new-fingerprint-inputting request section to the user. When necessary fingerprint inputting is performed from a new-fingerprint-inputting section, substitute authentication by a substitute authentication section is permitted. A result of the substitute authen-tication by the substitute authentication section is displayed on a service permission-or-rejection display section. The image inputted from a fingerprint-inputting section or a new-fingerprint-inputting section is stored into a substitute authentication means user information storage section.

CLAIMS:

1. A user authentication apparatus, comprising:

authentication means (14, 15) for authenticating a user by verification of biometrics data of that user, such data representing a biological characteristic unique to an individual:

acquisition means (21), operable when the authentication by said authentication means (14, 15) results in failure in the verification of the biometrics data, for acquiring new biometrics data of said user; and,

substitute authentication means (22) for substituting the verification of the biometrics data with the new biometrics data when the new biometrics data is acquired by said acquisition means (21).

2. A user authentication apparatus as set forth in claim 1, characterised in that it further comprises storage means (23) for storing the new biometrics data acquired by said acquisition means (21), and processing means (25) for performing search and pursuit of an illegal user based on the new biometrics data stored in said storage means (23).

3. A user authentication apparatus as set forth in claim 1 or 2, characterized in that it further comprises means (26)

for determining whether or not new biometrics data inputted so as to be used for the verification of biometrics have a quality suitable for automatic verification, and means (23) operable when it is determined that the new biometrics data do not have a quality suitable for automatic comparison for storing the newly-acquired biometrics data.

4. A user authentication apparatus as set forth in claim 3, characterized in that it further comprises means (26), operable when it is determined that the new biometrics data do not have a quality suitable for automatic comparison, for determining whether or not the new biometrics data have a quality suitable for use for the search and the pursuit of an illegal user, and when it is determined that the new biometrics data are suitable for use for the search and the pursuit of an illegal user, use of said substitute authentication means (22) is permitted.

5. A user authentication apparatus as set forth in claim 4, characterized in that the determination of whether or not the new biometrics data are suitable for use for the search and the pursuit of an illegal user depends upon determination of whether or not the newly-inputted biometrics data are proper and inputted by the user at the place used.

6. A user authentication apparatus as set forth in claim 5, characterized in that a correlation of a plurality of new

biometrics data acquired by said acquisition means (21) is measured to perform a determination of whether or not the new biometrics data are inputted by the user at the place.

7. A user authentication apparatus as set forth in any of claims 1 to 6, characterized in that at least a fingerprint is used as the biometrics.

8. A user authentication apparatus as set forth in any one of claims 1 to 7, characterized in that, upon storage of new biometrics data prior to the substitute authentication, at least a photographic image of a face and/or a figure of a user is taken when a fingerprint is inputted.

9. A user authentication method, characterized in that it comprises the steps of:

authenticating a user by verification by biometrics data of that user, such data representing a biological characteristic unique to an individual;

acquiring, when the authentication results in failure in the verification of the biometrics data, new biometrics data of said user; and,

performing substitution authentication for substituting the verification of the biometrics data with the new biometrics data when the new biometrics data is acquired by said acquisition means (21).

10. A user authentication method as set forth in claim 9, characterized in that it further comprises a step of storing the new biometrics data acquired by the step of acquiring the new biometrics data, and a step of performing search and pursuit of an illegal user based on the stored new biometrics data.

11. A user authentication method as set forth in claim 9 or 10, characterized in that it further comprises a step of determining whether or not new biometrics data inputted so as to be used for the verification of biometrics have a quality suitable for automatic verification, and a step of storing the newly-acquired biometrics data when it is determined that the biometrics data do not have a quality suitable for automatic comparison.

12. A user authentication method as set forth in claim 11, characterized in that it further comprises a step of determining, when it is determined that the new biometrics data do not have a quality suitable for automatic comparison, whether or not the new biometrics data have a quality suitable for use for the search and the pursuit of an illegal user and, when it is determined that the new biometrics data are suitable for use for the search and the pursuit of an illegal user, use of the substitute authentication is permitted.

13. A user authentication method as set forth in claim

12, characterized in that the determination of whether or not the new biometrics data are suitable for use for the search and the pursuit of an illegal user depends upon determination of whether or not the newly-inputted biometrics data are proper and are inputted by the user at the place that is used.

14. A user authentication method as set forth in claim 13, characterized in that a correlation of a plurality of new biometrics data acquired by the step of acquiring the new biometrics data is measured to determine whether or not the new biometrics data are inputted by the user at the place of the user.

15. A user authentication method as set forth in any of claims 9 to 14, characterized in that at least a fingerprint is used as the biometrics.

16. A user authentication method as set forth in any one of claims 9 to 15, characterized in that, upon storage of new biometrics data prior to the substitute authentication, at least a photographic image of a face and/or a figure of a user is taken when a fingerprint is inputted.

17. A user authentication apparatus substantially as herein described with reference to and as shown in the accompanying drawings.

18. A user authentication method substantially as herein described with reference to and as shown in the accompanying drawings.

34.

Application No: GB 0030061.6 **Examiner:** John Donaldson
Claims searched: 1 to 18 **Date of search:** 4 January 2001

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): G4R(REP, REX, RHA, RHB, RPE, RPX); G4H(HTG)

Int Cl (Ed.7): A61B 5/00, 5/117; G06K 9/00; G07C 9/00

Other: Online:WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	GB 2345371 A (OMRON), see abstract	-

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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